APPARATUS FOR MEASURING THE VERTICAL ACCELERATION DUE TO THE SWELL

The present invention relates to an apparatus for measuring the vertical acceleration due to the swell or ocean waves, the slope of the free sea surface, and the direction of the swell.

For measuring such parameters, it is necessary to have a rectangular-coordinate system which is fixed in the space and may be defined as follows:

Oz axis is oriented as the vertical up-line of the spot, i.e. oriented as the plumb line;

Oy axis is oriented towards the magnetic North, and

Ox axis is oriented towards the magnetic East.

Present apparatus are known for measuring the swell parameters or ocean waves, which are based on two different principles. In one case, the measuring assembly is outside of the medium and, in the other case, it is included in the medium.

With respect to the apparatuses operating outside of the medium, three projects are presently under experiment. In the SEASAT project, a radar pulse is transmitted from a geostationary satellite, the backward pulse being analysed for recorvering the amplitude and the direction of the swell. In another project, an HF radar is used which transmits a radar pulse which is reflected by the water surface after having been reflected by the ionsphere. The amplitude and the direction of the swell must be determined by measuring and analysing the Doppler effect on that twice reflected pulse. A third project makes use of a direct radar which transmits a radar pulse directly towards the water surface. The reflected pulse is analysed to determine the amplitude and the direction of the swell.

When the measuring assembly is inside the medium, it is located in a buoy which is directly moved by the swell and which has three degrees of freedom. In such a case, the rectangular-coordinate system wherein the measure is made must be first defined. Two possibilities may be contemplated: the rectangular-coordinate system may be locked either to the vertical line or to the water surface.

In the vertical locking, a gyroscopic equipment may be locked on the vertical line of the spot. It is the most worked and explored solution. But, if it seems rather promising, it has the disadvantages of being heavy and consuming. The gravity may also be used for locking the rectangular-coordinate system to the vertical line. A spherical swell buoy is known which operates with an accelerometer mounted on a circular plate moving inside a sphere. The external reference is the gravity acceleration $\vec{g}$ which is oriented according to the vertical line at any spot of the globe. The locking is entirely dissociated from the measure of the swell acceleration. Thus the oscillation frequency proper to the movable equipment must be quite low with respect to the frequency band of the swell spectrum (0.1–60 s). In practice, if measuring and locking are physically separated, the detector must have a large size, the sphere must be filled up with a liquid such as glycerol, and the wire which supports the movable equipment must have very good mechanical characteristics. Such an equipment makes possible to measure the vertical acceleration vector of the swell only.

A purpose of the present invention is to provide a measuring apparatus in which the rectangular-coordinate system is locked to the sea surface, that apparatus making it possible to determine the vertical acceleration due to the swell, the slope of the free sea surface and the direction of the swell, while affording a number of advantages with respect to the existing equipments.

It may be said that, quantitatively, the measuring equipments operating outside of the medium make use of sophisticated techniques and materials, with an important personnel and an important budget.

Regarding the measures inside the medium, the gyroscopic lock buoys are generally bulky and, therefore, are not easy to utilize, more specially as they imply important reserves of energy. The system making use of the gravity, which has been the most worked for the last years, has, however, the disadvantage of giving only the vertical acceleration due to the swell.

In the present invention, a small-size and low consumption buoy is used, which makes it possible to obtain the parameters: vertical acceleration, slope and which direction of the swell, and has a number of advantages in the scientific field, for the study of the sea medium and the swell phenomenum, as well as in the technical field, for the knowledge of the stresses which the sea is subjected to.

According to a feature of the invention, an apparatus is provided for measuring the characteristics of the sea swell, which comprises a buoy of which the main plane follows the free surface of the water, an accelerator mounted on the axis of the buoy, two perpendicular accelerometers mounted in the main plane of the buoy, and a three-axis magnetometer.

According to another feature of the invention, the axis of the three-axis magnetometer are coincident with the axis of the accelerometers.

In addition to the detectors, the buoy carries the power supply and electronic material needed for processing, recording and/or transmitting the data relative to the swell.

The acceleration due to the swell is perpendicular to the free surface of the water. Thus, the accelerometer mounted on the buoy axis measures the sum of the acceleration due to the swell and the gravity acceleration projection $\vec{g}$ along the axis of the buoy.

The two orthogonal accelerometers mounted in the main plane of the buoy make it possible to measure the components of the vector projection $\vec{g}$ in that main plane. If the values of $\vec{g}$ and of the components of $\vec{g}$ in the main plane of the buoy are known, the vector projection $\vec{g}$ along the axis of the buoy may be derived therefrom. Then, this value is deducted from the value measured by the first accelerometer. The result is the value of the acceleration due to the swell.

The value of the projection of vector $\vec{g}$ along the buoy axis makes it possible to derive the angle of that axis with the vertical line, which directly provides the slope of the free surface of the water. From the value of the acceleration caused by the swell and from the value of the angle with the vertical line, the vertical acceleration caused by the swell may be derived.

The magnetometer makes it possible to determine the earth magnetic field vector with respect to the buoy. The direction of the swell is defined as the angle between the horizontal projection of the vector of the acceleration due to the swell and the horizontal projection of the magnetic field vector. The horizontal plane is defined with respect to the buoy if the vector $\vec{g}$ is known. It is thus possible to determine the direction of the swell.